Boost Up Of Safety Enabled Drilling Operation Of Ultra Deepwater Reservoir Employing Hybrid Real-Time Operation Centers (RTOC) & Software Tools

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Abstract: The process safety management in the Exploration & Production is enhanced by digital coaction amongst operators and service providers. On the other hand, the data obtained from surface is associated with the drilling contractors who are not interested in the design of real time data analysing tools. The analysing tools were employed in the oil & gas industry during the initial phase of exploration that too in the seismic processing and the interpretation of subsurface three dimensional & two dimensional contrast images. The present conditions is the right time to develop a real-time operation center (RTOC) in association with a drilling contractor as the upstream field is facing the financial challenge of low price to their products. More innovative techniques in their Exploration & Production will be fruitful, when the field suits up. This paper will discuss in detail about the role of drilling contractor in applying real time data analysis and operation center for the safety enhanced ultradeep water drilling process.

IndexTerms: Integral Circuits, Operating Center, Process Integrity, Stack Sensor, Ultradeep water, Washout, Well barrier

1. INTRODUCTION

1.1 Ultradeep Water Drilling

It refers to the exploration and exploitation of hydrocarbon operations carried out in the offshore with depths greater than 1500 meters. Drilling beyond 500 meters in offshore leads to various challenges namely lack of technology, infrastructure and technicians to operate. When we drill beyond 1500 meters we face more challenges and the normal offshore rigs are not been used because of storms, hurricanes and unstable surface conditions at the sea level we have to use semi-submersible rigs and drill ships. Till 2018, 1974 offshore deepwater wells were drilled [1]. The number of wells drilled in 2017 & 2018 are 128 & 35 respectively [2]; [3]. This shows the reduction in the number of ultradeep water wells due to the fact that the downhill trend of crude oil [4]. With respect to depth we face several problems such as vibration of drillstring due to loop & eddy currents, presence of thrust fault zones, unidentified & unpredictable pressure zones, sudden formation of gas hydrate, lost circulation regions and so on. This made ultradeep water drilling a complex process.

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1.2 Safety enabled drilling technology

In ultradeep water drilling of offshore, most often accidents occurs in the redzone. The redzone is the area of the rig floor where the probability of injury is high due to the use of heavy drilling equipment. This AI enabled safety technology is a combination of artificial intelligence and light detection and ranging technology commingled with next generation computing technology is highly effective in the operation of redzone in drill ships and semi-submersible ships. [5] With the increasing availability of drilling data such as Rate of Penetration (ROP), Weight on Bit (WOB), Flow of water, Lithological description, Equivalent Circulating Density (ECD) and the advanced & safety enabled data transformation technology between the offshore rig sites and well operation centers paved the way for the development of Real-time operation centers (RTOC) in the outset of 21st century, which results in the collaboration environment among the operating company & service providers that offers increased support and ideal utilization of technical resources to ameliorate process safety and operational efficiency. [6] Generally the drilling contractors rely on the surface drilling data [22]; they were not concentrating on the real-time analytic tools. The negative outcome of the above is the dependence of wellsite information transfer standard makeup language (WITSML) for data processing and embedded system tools for the creation of data and models for the improvement of efficiency of drilling rig which is not accessed by the operating company and service providers. [7]

1.3 Development of Software

Necessary prospects of standard operating procedure (SOP) and its executional functions such as operation discipline and working condition of the equipment can be turned to service providers in drilling instantly if adequate facilities are in place. Software developers in guidance with drilling engineers as subject matter expert (SME) started writing programs, codes and algorithms for operation identification and detection of problems in the rig which heightens the operational safety and monitoring [8]. The conjunctive task countenanced the conception of altered instrument on the basis of the company requirement and rendered an organized procedure to execute, customize and service the tools time to time. During the planning of project itself, it is concord that the overall operational safety and functional performance of the drilling rig can be regulated by well control, well barriers assessment, equipment safety operational window, prediction of drilling problem, process sensor integrity and monitoring of blowout preventer (BOP). The abnormal conditions during the drilling operation is reported to the RTOC technicians and they respond instantaneously by comparing the earlier problems encountered and its remedial counter action carried out which is available in the database. This enables the dilemma in the decision to be taken and brings unanimity amongst the people. It is time saving, cost-effective and leads to continuous improvement in the drilling and database.

1.4 RTOC – A boon in drilling

RTOC provides a methodological analysis of different data sources from the third party companies and the drilling rig owners where they create the platform, the integration and synchronization of data related to drilling parameters. Recent advancements have affirmed the collection of drilling data such as drilling draw works, mud circulation system [10], rotating assembly, BOP control systems, subsurface petrophysical data, measurement while drilling (MWD), logging while drilling (LWD) from various sources in the unified data interface in the same real-time drilling operation centers which substantially increasing the ease of decision-making process. [9] Drilling data from the field is collected by real-time analytics using internet of things platform, then data analysis performed. It offers the consolidation of data obtained from drilling systems and well control and the basic geographical data such as humidity, temperature, climate and so on from the unit drilling data server assembly. The modes of operation are preprogramed as the primary source of information and is analysed in real time if there is any deviation. The algorithmic program devised by the RTOC team gives an alarm in case of any unnatural condition. The operational tools are broadly classified into six major categories such as well control, well barrier assessment, equipment safety operational window, prediction of drilling problems, process sensor integrity and monitoring of BOP and all the above parameters are associated with the process safety and related with the industry's performance track record.

2. CUSTOMIZATION OF CONTROL BOARD

A customized control board setup allows the RTOC programmers to write algorithms, data structures and image processing systems which are flexible to enhance the fidelity of real time observation of datum and accomplish serviceable requirements [11]. The control boards are necessary during the development stage where major drilling activities taken place which needs continuous monitoring and it aids in comparison of the real time data with the already existing data thus ensure the organised & integrated procedure of decision-taking in a short span of time.

3. VARIOUS PHASE OF PROJECT – TIMELINE HIERARCHY

The drilling contractors operates all over the world to drill a well under risk bearable technical service contracts has the data related to the drilling parameters such as kick-off point, bottom hole pressure, clay swelling, pressure regimes, fracture gradient, rate of penetration, weight on bit and BOP data such as kick range, kick tolerance, kill mud weight and all the other subsurface data. Those data has to be gathered and transferred to the control panels installed in the new location where drilling rig operates. The primary job of the RTOC engineers is to monitor the routine drilling operation. Based on the available geological and geographical data, the well parameters are correlated with the current well. By comparing the data, the RTOC team has to identify the potential risk zones which causes drilling problems such as stuck pipe, sudden influx of formation fluids, clay swelling and is to be documented and also found out the way to encounter it. The existing control panel system was used mainly for visualization of 3D images and data [12]. It is already programmed with the threshold limits of drilling and BOP parameters, if it exceeds the limit it automatically activates the alarm. The RTOC engineers working in the control panel will be given basic training in the operation of rig, BOP and safety procedures which helps in the handling of problems easily in critical stages using apply of common sense. The above procedure functioned comparatively good and avoided certain conditions from intensifying, thus allows the evolution of new process and addition of results in the existing set of procedures. It is because of the lack of communication among the RTOC professionals as a result of problems aroused during the inception of drilling. Various attempts were made to improve the efficiency of the operation but it's a sleeveless errand. The operation should be motley based on the process safety risk and intended to step-up the efficiency without extra use of manpower. The way the problem was dealt, a switch over expressed as a result of it
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4. NEED OF CUSTOMIZATION IN ANALYTIC TOOLS

The readily market available WITSML based analytic tools were deployed in the field for testing and the results were not appreciable and is inadequate to meet the necessities of the drilling contractors. Those analytic tools failed because of the size and type of the data where it can't perform ideally. Customizing the analytic tools to meet out the needs of drilling contractor is not found to be economically feasible because the customization is only for a particular well. Therefore an analytic tool has to be designed for more than one well which fits to give solution. [14] To overcome the above problem, the drilling contractor has to give their expectations to the software company who provides platform for the control board in the real-time operation. Being the on field engineer, the driller knows the details & nature of the well and rig equipment thoroughly. He knows the operational issues in the optimization of equipment. Both the software developers and driller can work together to root out optimization discrepancy. It should be noted that the software company has to adapt to the needs of the drilling contractors but the software professionals may not be aware of the drilling process. Orientation training has to be given to the drilling operators in the field of programming and control boards, so that they can develop their software accordingly. After the drilling engineers can develop the software and it may be scrutinized by the software professionals for accuracy. Later on it will be deployed to the real field for operation. [13] The Automated software identification enables the engineers to perform more than one operation in a time without any complication in the operation. If a problem is notified, the system automatically activates the alarm which in turn grabs the attention of engineers and the drilling crew; they can perform the remedial work accordingly, if necessity arises out.

The C program for the drilling operation using RTOC software is as follows:

```
#include<conio.h>
#include<stdio.h>
#include<iostream.h>
void main()
{
int i,j,k,l;
printf(" existing information available in onshore data proceesing centre\n");
for(i=0;i+1;i++)
{
printf("analysing offshore rig to fit for existing RTOC software\n")'
for(j=0;j+2;j++)
}
printf("creation of new software &control board for operation "\n);
for(k=0;k+3;k++);
}
printf ("real find analytics\n");
for(l=0;l+4;l++)
{
getch ();
}
```

5. MODUS OPERANDI

The drilling rig which was manufactured in the last 5 years is integrated with the software for monitoring, transmitting and collection of data from the well. But the real fact is that ordinary drilling crew in underdeveloped countries still works with the data gathered before two decades. A general workflow has to be designed by International Association of Drilling Contractors (IADC) & International Well Control Forum (IWCF) for the sharing of data within the operating and service companies which will be helpful in addressing the problems in a well, rig and its solution. When an abnormal condition arises out, the alarm beeps on the RTOC workstations and depending on the intensifying nature of the condition it automatically alerts the supportive teams. Once the alarm is notices, it is verified for its originality by considering the documentary evidences from real-time surveillance cameras, proportional integral derivative circuits (PID), Manual drilling report by drilling superintendent and other available necessary supporting documents. After verification, the follow-up procedures will be communicated to the onsite personnel officially through e-mail and telephone. In rare case scenario, when the RTOC engineers unable to perform the operations due to lack of experience in that particular well conditions, they may contact the nearby technical team immediately to respond and pre-set control boards accordingly which provides accurate decision making.

A well comprises of various sections based on the lithology. Numerous tests such as well barrier test, subsea BOP pressure test, casing pressure test, well inflow test, Trip-in and Trip-out of bottom hole assembly (BHA) after drilling out each section is officially documented and is known as One-page report. It consists of all the important actions carried out during the operation such as challenges encountered and its remedial action and other important aspects for the successful completion of the project. [15] The information in the report were transferred to the higher authorities, if there is any discrepancies it will be discussed in the monthly review meeting and immediate remedial measures carried out may be appreciated in presence of tool pushers, floor man, driller and offshore installation manager (OIM).

6. Concept of Six dimensions

For the improvement of the efficiency of the RTOC project, the work is fractionated into six category as follows:

- ❖ Well control
- ❖ Well barrier assessment
- ❖ Equipment safety operational window
- ❖ Prediction of drilling problems
- ❖ Process sensor integrity
- ❖ Monitoring of BOP

6.1 Well control

It is the process of maintaining the annular pressure and formation pressure to prevent the intrusion of formation fluids into the borehole. [16] The following parameters have direct influence on well control and are volume variation during trip-in & trip-out, measurement of amount of mud returned to mud-pit during drilling, pressure loss-gain occur during drilling and critical flow check for any influx of fluid. The RTOC engineer monitors the above parameters and gives signals to field engineers in case of any emergencies.

6.2 Well barrier assessment

Well barrier is the imaginable zonal layer which prevents the intrusion of fluids from the formation into the wellbore and moves towards the surface. There are two types of well barriers:

- ❖ Primary well barrier – Drilling mud acts as a primary well barrier which prevents the entering of formation fluids into the wellbore.
- ❖ Secondary well barrier – In case of failure of primary well barrier, the formation fluids enter into the wellbore and start moving upwards to the surface. It can be prevented by wellhead, blow out preventer, cement and are called as secondary well barrier.

During drilling, the conductor casing is lowered without using drilling mud as there is no pressure zone, when we go deeper, we have to use drilling mud to maintain borehole pressure in the zones of surface casing, intermediate casing and production casing as we encounter the abnormal pressure zone. During this, we need both the primary & secondary well barrier till we hit the hydrocarbon reservoir.

The monitoring of well barrier assessment by RTOC engineers is done regularly in two alternate methods:

- Real – time barrier monitoring
- Creating holding points whenever a well barrier is tested

In RTOC both the static and dynamic pressure is calculated. Various tests such as real-time overbalance, equivalent circulating density (ECD), riser safety margin (RSM), inflow test & BOP pressure test were conducted to evaluate the well integrity.

6.3 Equivalent safety operational window

The major equipment used in drilling which can be accessed remotely were drillstring, blow out preventer, motion compensator and pipe handling system. This equipment has the specific safety range for its operation. The RTOC engineers should be aware of the safety operating window of the equipment.

For ensuring the safer drilling operation, Crown Mounted Compensator (CMC) is installed. CMC tool applies a uniform tension to the drillstring and counterbalances the rig movement. When the crown block rotates, the drillstring passes over the slip joint, BOP, well head installation, casing and casing shoes and then enters into a new zone, after that the CMC shall be activated for the improvement of safety and efficiency of the drilling process.

There may be problems even within the casing shoe, to overcome this, the RTOC engineers developed an algorithm for real-time monitoring of drillstring and can activate CMC at any time when restriction occurs.

In the Trip-in & Trip-out sheet, the CMC activated depth is recorded for the reference of the operator.

6.3.1 Kick Prevention

When a kick is detected during drilling immediately the well is closed to avoid the development of kick. To overcome the kick, stripping has to be done. The process of running the drillstring through the BOP during the well shut-in and is called as stripping and is executed with annular BOP only. But the annular closing pressure is dependent on the annular type, wellbore pressure and cross-sectional tubular diameter of the BOP. If the annular closing pressure is not actuated correctly, it causes wear on the annular BOP which results in the failure of the stripping process. The RTOC engineers programmed an algorithm to monitor the annular closing pressure. It performs the stripping process by the combining action of moving drillstring and annular closing of BOP. The RTOC engineers will send the correct closing pressure of annular BOP to the operation site by picking the correct parameters from the look-up table by comparing the current wellbore pressure.

6.4 Prediction of drilling problems

Due to the unpredictable and complex nature of the subsurface formations, the drilling equipment and bottom hole assembly (BHA) components such as drillstring, rotary steerable motor and drill bit gets damaged. Understanding and expecting the nature of the problem to be encountered is the key to prevent such damages, thereby minimizing the loss incurred to the company. The frequently encountered problems during drilling are drillstring, drillstring failure, lost circulation and wellbore influx. Drillstring is the drilling component which comprises of heavy weight drillpipe (HWDP), drill collars & drillpipe.

6.4.1 Drillstring sticking

It is the condition where the drillstring unable to move along either the horizontal axis or the vertical axis of the wellbore. It is of two types

a) Differential sticking
b) Wall sticking

Differential sticking occurs as a result of low pressure in the formation & high pressure inside the wellbore, which acts over the entire drillstring and makes it moves towards the walls of the formation and results in stuck pipe. During drilling, the drilling mud is circulated from the drillstring through the annular side and some amount of chemical additives will gets deposited along the sides of the formation and prevents the entering of drilling mud into the formation and is called as filter cake. The thickness of filter cake increases with time and as a result of pressure differentials among the drilling mud & formation pressure, the drillstring got stuck with the filter cake and this phenomenon is called as wall sticking.

6.4.2 Drillstring failure

When drillstring is subject to stress, it fails. While pulling out the drillstring, the tensional force is sometimes higher and results in tensional failure. During drilling, the torsional force acting along the opposite direction of rotation of drillstring and damages the drillstring. [23] In sometimes, the chemical present in the drilling mud induces corrosion in the drillstring and results in failure.

6.4.3 Lost circulation

The hydrostatic pressure in the annulus is high due to mud weight and the formation being weaker, the drilling mud enters into the formation and this condition is reported as lost circulation. [17]

6.4.4 Wellbore Influx

It is a condition in which the formation fluids enter into the wellbore due to the formation pressure is high in comparison with the hydrostatic pressure of the well and this phenomena is termed as kick. If kick is not controlled, it results in blow-out which incurs a huge loss to the company and pollutes the environment drastically. [18]

6.4.5 Mitigation of drilling problems

The drillstring sticking, lost circulation and well influx are the problem which has been prevented by sending the optimal amount of drilling fluid for drilling. The RTOC engineers developed a dashboard which will monitor the flow of drilling mud into the wellbore. It can automatically regulate the flow of drilling mud. Drillstring failure is the most serious drilling problem and it needs a serious approach. To overcome this, the drilling contractor devised a specified control panel and keeps the RTOC engineers more vigil and fastly assesses the well conditions before they become worse and took remedial measures to palliate or avert the situation. The top drive rotates the drillstring it induces vibration and provides tensional load on the drillstring and drill bit. The vibration may increases the torque which causes connection damage and ends up with washout. In

some rare case scenario, if washout is not notices early on, it results in drillstring twisting and drastically increases the operating cost.
The Mechanical specific energy (MSE), drillpipe connection overtorque and washout are inter-related with each other.
The mode of operation of RTOC engineers with the above three parameters is discussed here.

6.4.5.1 Mechanical Specific Energy (MSE)

MSE gives the quantum of energy (strength) needed by a drilling setup to drill a unit volume of formation and reciprocate it with the compressive strength of the rock being drilled. MSE depends on weight on bit (WOB), surface torque, bit rotation per revolution and rate of penetration (ROP) for a given borehole. Whirl vibration, bit balling vibration and stick-slip vibration are the major vibration which occurs in the bottom hole assembly that limits the performance of drill system and it can be subdue by appropriate use of MSE for better and longer bit runs. [13] The drill bit is the costliest component of the drillstring assembly; the vibrations induced during drilling damages the drill bit which in turn minimizes the drilling rate. It leads to the increase of project timeline and financial cost. It can be minimized by tuning MSE which increases the life of the bit and reduces the drillstring failure as well. The RTOC engineers creates a database which comprises of the compressive strength of various sedimentary rocks such as sandstone, breccia, limestone, conglomerate, chert, dolomite, calcite and types of drill bits namely milled-tooth bits, tungsten carbide insert bits (TCI), polycrystalline diamond compact bits (PDC), impregnated bits, diamond bits to be used to drill it.

6.4.5.2 Drillpipe connection overtorque

The drillpipe and drillstring assembly in a drillstring assembly in a drilling rig is subject to various loads with respect to depth and it leads to unsuccessful completion of drilling a well. The drillpipe and drillstring setup is connected as likely of the normal pipe-pipe joint like threads. The pipe thread design is the most complicated process in the design of drillpipe. Drillpipe connections are designed mechanically to hold upto a certain torque only. But the torque value varies during the drilling process because of the induced vibrations which results in the stick and slip of the drill pipe connection and ends up in higher torque than what we planned. Hence, before running the drill pipe it is necessary to check and apply correct & constant torque to the drillpipe connection. If the torque is not maintained properly, the torque will builds up. The drillpipe connections assembly being the lengthier setup, there is a feasibility of the sensors for sending the incorrect torque readings or make-up torque settings. Both the above cases can cause severe damage to the thread connections, which leads to failure of drill pipe connections thus

i. Increases rig downtime
ii. Connection repairs
iii. Shortening of tubular life

All these three parameters will have severe impact in the project impacts by lengthening of the project duration and repairing costs associated with it. To fend off the above problems, RTOC engineers includes a specific column in their dashboard which displays the torque routine to record and analysis of make-up torque required for tubular run in hole. An alarm will be sent to the RTOC engineers, when the employed make-up torque is higher or lower than the recommended value or when breakout torque is higher than the desired range.

6.4.5.3 Washout

It is the process of allowing the drilling mud to circulate along the annular space between the drill string and the subsurface formation through the holes present in the drillpipe and drill collar. [19] Usually, the washout is small at the commencement of the operation and it increases with the time where the drilling mud deteriorate through the constant stress and makes it more substantial making the standpipe pressure to drop and allows drillstring to break.

6.4.5.3.1 Reasons for Washout

The following are the reasons for washout in a well:

a. Torque lesser than the recommended range results in poor sealing at the drillpipe connections.
b. Torque higher than the recommended range leads to damages in the thread sealing.
c. Damage due to the shock during the pipe connection using tongs for positioning on the rotary table.
d. Presence of hydrogen sulphide and other corrosive chemicals in the drilling mud.

6.4.5.3.2 Detection of Washout

Washouts are detected by comparing the surface flow and turbine rotation of MWD (Measurement While Drilling) which is readily available at the well operator functional dashboard [19]. There is only one possibility of the drilling mud to escape, the flow of mud is kept constant in the drillstring and is maintained from the surface but it escape through the poor sealing before reaches the lower section of the string and can be detected by decrease in the turbine rotation of MWD and ultimately results in washout. The MWD tool readings will be transmitted to the RTOC engineers and in turn, they send the respond signals to overcome the situation.

6.5 Process Sensor Integrity

A decade ago, the drillers were trusted on their hunch and experience and are over now. Nowadays, the modern rigs have various instruments and features which give accurate readings and measurements such as pressure, temperature, loads, torque, ROP, WOB, mud circulation and pit levels. [20] Major equipment has a tendency to give superfluous readings, which activates the alarm in a reflex manner whenever the values are over a predefined level. When one or more parameters are recorded using a single sensor, there is a possibility of neglecting the readings, an additional supervision is needed for this condition. Numerous techniques have been followed up for checking of surplus pit volume sensor readings, acquiring supererogatory pressure readings and comparison of hook load against calculated weight. The latter is accomplished by employing a semi-automated approach where by the RTOC engineers knows the standard weight of the equipment used in drilling and are:

Maximum Load: Hoisting system + Riser running tool

Maximum Load: Hoisting system + Riser running tool + 90ft. Slick riser joint + BOP

The dashboard automatically finds the minimum and maximum load and compares both the values to the calculated hook load. The dashboard records the measurements and retrieves it anytime for history matching with previous measurements to key out a sensor range over a time that could symbolize the deterioration of the measurement device.

6.6 Monitoring of BOP

A blowout preventer is a large, specialized mechanical device weighs upto 400 tons which consists of valves used to seal and control the flow of uncontrolled oil or gas from the subsurface formation as a result of kick. It is installed during drilling, well completion, well testing and workover operations. Kick is the sudden influx of formation fluid either gas or oil into the wellbore due to the low pressure in annular zone. Kick not controlled, it leads to blowout. [21] Once the kick is detected, the annulus is closed. The kill mud is circulated into the drill string to overcome the kick. The kill mud is circulated into the drillstring to overcome the kick. If it is not controlled means, forcibly we are pumping the kill mud through the kill line connection and are called as bull heading. If both the process fails means the last defence mechanism is the operation of BOP. Because of its importance in the drilling operation, the real-time operational monitoring plays a major role in the process safety. There are two types of RTOC operations in the BOP.

a) Emergency Disconnect Sequence vs Ongoing operation
b) Differential pressure acting on each valve

6.6.1 Emergency Disconnect Sequence vs

Ongoing operation

When the rig crosses the maximum inclination limit for a vertical well and maximum allowable pressure range, the Emergency Disconnect Sequence (EDS) is activated on control panel which is an automatic operational sequence of Lower Marine Riser Package (LMRP) disconnection. The objective of EDS is to leave the well in a safer condition after disconnection. The RTOC sends a status signal to the selected EDS on the rig. Based on the existing fundamental drilling data such as hook load, mud pump pressure, rotation per minute and block position, a set of logics were created for the automatic identification of the ongoing operation. The ongoing operation is monitored in real-time and matched with the pre-set EDS data, if there is any mismatch, an alert will be sent to the RTOC centers through signals and mail.

6.6.2 Differential pressure acting on each valve

In an offshore environment, external pressure capacity is the performance concern in the design of sealing for pressure-containing joints for subsea BOP systems. It is much needed due to the increase of the water depth and annular pressure. It is the area of special attention because of the possibility for unforeseen loss of fluid inside the drillstring due to presence of gas-in-solution, lost circulation to the formation and fluid inflow. When the BOP is installed on the bed, apart from the pressure inside the subsurface formation, the BOP encounters the pressure from external environment such as water depth and pressure density and is to be calculated easily. To measure the pressure inside the BOP, two sensors are fixed. They are

Table 1: *Type of Sensor and its location*

S.No	Name of Sensor	Location
1	LMRP	Top of the BOP Assembly
2	Stack Sensor	Top of the BOP Assembly

The pressure acting on the BOP is the combination of both the pressure inside and outside the BOP and is called as negative pressure it can be calculated in real time. Apart from using the sensor readings and preventer limits, there is a possibility of calculating the reverse pressure acting on a closed preventer in real time. To get the exact BOP operation status in real time, the manufacturers has to give the maximum pressure withhold limit of each components of BOP such as annular preventer, blind ram, blind shear ram and pipe ram. If the reverse and negative pressure limit of the components are fixed and that can be fed into the dashboards of RTOC operation centers. If the calculated pressure goes beyond the limit of manufacturers pressure ranges, the RTOC engineers will be alerted and signals were sent to the field personnel thus increases the reliability of the operation.

7. Execution of Six Dimensions Concept

The identified six categories have been accessed regularly based on their prompt result on process safety, availability of resources, complexity of operation and time required for development. This procedure transfers data into useful information for the future and aids in the faster detection of abnormal conditions. This process has more data in comparison with the entire knowledge of the drilling crew. The abnormal situations and conditions were pre-programmed in the RTOC dashboard; it alerts RTOC engineers in case of any abnormality. After verification of the situation in the field, the RTOC engineer communicates the on field drilling crew and suggests the early possible remedial measures to counterbalance the situation.

8. Recommendations and Conclusions

1. Need of Investment – RTOC outcomes rely directly on the availability of data. Huge investment is needed in the storage of drilling data in servers.
2. Operational flexibility – The primary objective of the drilling operation is safer drilling for both the personnel and environment and is achieved by real-time analytics software tools developed by the RTOC engineers and offers flexibility in the operation from well to well.
3. Safer operation - The standard procedure and guidelines provides safe and efficient operation. The algorithms and programming is refined to lighter complexity. Time-Surveillance algorithms detect deviations in complicated operations. The real-time monitoring allows the simultaneous error rectification in timely basis which makes the operations safer.
4. Novel technique – Improved results were attained by employing a hybrid technique with detection based algorithms on the automatically detected mode functioning in the backdrop along with the specific operations carried out by RTOC engineers.
5. Time Management – Drilling engineers are responsible for the monitoring of operations and development of

emergency detection algorithms in association with the software engineers. Whenever the emergency situation arises, the drilling engineer in discussion with RTOC engineers arrives out with a possible solution in a shorter span of time.

6. Proctored protocol – A well-integrated communication protocol is necessary for the successful completion of the emergency arises out in a project. It should consists of what type of alarm for various range of emergency situation, what are the technical things to be communicated, to whom the information should be reported first and who are all the sub-ordinates should follow up the process and the stipulated time span required for the mitigation of the alarming situation.
7. Future planning – During the initial stage of the project itself, the sub-projects of the well which has more prone to affected by external parameters are prioritized and their remedial measures also to be defined in advance. This ensures the RTOC engineers to handle the situations easier without any struggle as the problems are anticipated and is need to be followed in all the phases even if there is no problem, which aid in the successful delivery of the project and gives input to the future operations.
8. Data confidentiality – To maintain the data confidentiality, finger print and other biometrics may be used to access the critical data and operation of major oilfield equipment such as kill line, choke line, manifold and operation of BOP.
9. Cost Cutting – The RTOC enables less use of manpower for the operations. It results in reducing the financial burden of the employers for paying salary and other necessary amenities for the workers. Thereby, the time value of money, project value and rate of return is kept high.

Abbreviations and Acronyms

LIDAR – Light Detection And Ranging
ROP – Rate Of Penetration
WOB – Weight On Bit
ECD – Equivalent Circulating Density
RTOC – Real-Time Operation Centers
WITSML – Wellsite Information Transfer Standard Makeup Language
SOP – Standard Operating Procedure
SME – Subject Matter Expert
BOP – Blow Out Preventer
MWD – Measurement While Drilling
LWD – Logging While Drilling
IADC – International Association of Drilling Contractors
IWCF – International Well Control Forum
PID – Proportional Integral Derivative circuits
OIM – Offshore Installation Manager
RSM – Riser Safety Margin
CMC – Crown Mounted Compensator
HWDP – Heavy Weight Drill Pipe
MSE – Mechanical Specific Energy
TCI – Tungsten Carbide Insert bits
PDC – Polycrystalline Diamond Compact bits
EDS – Emergency Disconnect Sequence
LMRP – Lower Marine Riser Package

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